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Cursor controller for display device - has device which produces compensation adjustment signal based on ratio of operator reaction time to cursor motion rate

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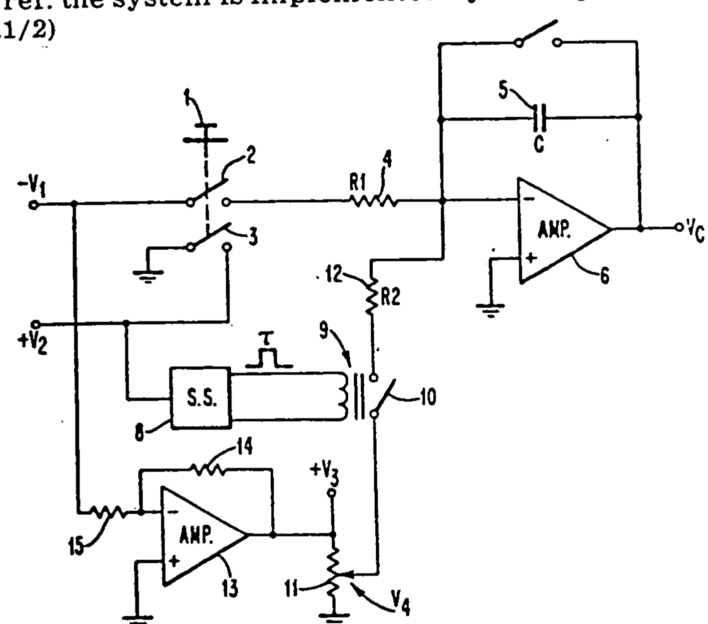
In the device the position of an element proceeds at a rate in response to a first operator signal, and the operation is terminated in response to another signal. A resistor (4) is provided for establishing a signal responsive to the cursor motions rates and the resistor (11) establishes a signal indicative of operator reaction times. A controller (13,14,15) is included which produces an end point compensation adjustment signal based on the ratio of the operator reaction time signal to the rate signal.

Another arrangement (516) provides an end point position by applying the end point compensation adjustment signal negatively to the end point at the time of the second operator signal. Pref. the system is implemented by microprocessor. (12pp Dwg.No.1/2)



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(54) **Manually controllable device such as a cursor control.**

(57) A controller is provided for manually actuated movement of a cursor in an interactive display wherein overshoot in the positioning of the cursor when rapid movement is involved is compensated employing a factor involving the user's reaction time and the motion rate of the cursor. Preferred implementation is by microprocessor, although analog exemplification is described.

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MANUALLY CONTROLLABLE DEVICE SUCH AS A CURSOR CONTROL

DESCRIPTION

Technical Field

The technical field of the invention is that of manually controllable devices e.g. for effecting controlled movement of an index member or cursor on the face of a display. A display when used as a communication medium for a data processor is provided with a moveable indicator called a cursor that is actuated by an operator using the controls for the display. The term cursor was also used as a name for the light pen or stylus used in displays where information is entered by touching a point on the surface of the display. This invention relates only to the type of cursor where the controls of the display are employed.

The cursor defines the point of attention of the person working with the display and is moved from place to place in the display area in interactive communication between a display and an operator. With such a system, the operator's psychomotor limitations, which determine his ability to precisely move the cursor from one part of the display to another, become more critical. The usual control apparatus for moving the cursor provides either single spaces and takes a long time for moving the cursor a significant distance, or provides a fixed or exponential movement rate with a tendency to overshoot which requires separate operations for correction.

Background Art

The cursor control problem has received some attention in the prior art.

Circuitry has been provided in connection with cathode ray cathode ray tubes to control the position of a cursor by dividing the screen into particular areas and setting up errors in a register. This is illustrated in U.S. Patent 4,101,879. A method of providing a scan control by a prolonged depression of a key is illustrated in U.S. Patent 4,020,391. In U.S. Patent 3,541,521 there is set forth a control by a handle of the acceleration of a cursor in which the cursor moves faster the more rapidly the handle is moved.

The invention as applied to a display is concerned with a control whereby a cursor can be rapidly moved from one position of the display to another and then located at a precise position without some additional form of manual correction being required.

Description of the Drawings

FIG. 1 is a functional circuit diagram of a cursor controller according to the invention.

FIG. 2 is a cursor position control signal generated by the circuit of FIG. 1.

Disclosure of the Invention

The invention is exemplified by a cursor controller for a display in which, by a psychomotor operation such as the depression of a key, the display apparatus causes a cursor to move from one portion of the viewing area to another, and when a selected location is reached, the controller provides a correction compensation signal to precisely position the cursor. The compensation signal is a function of the speed with which the cursor is moving and the reaction time of the operator and operates to correct for overshoot and move the final location of the cursor to the desired position. As the cursor moves on the display, the

controller provides a correction factor for errors in the operator's estimate.

The principles of the invention are illustrated functionally in the circuit of FIG. 1 for generating the position signal of FIG. 2.

While the preferred embodiment with current technology is that of an integrated microprocessor, for purposes of functional illustration the circuit of FIG. 1 is provided. In FIG. 1 the functions that would be embodied in the microprocessor to generate a cursor position in digital form in a preferred embodiment are shown generating the position signal of FIG. 2, in analog form. The function being performed by the illustrative circuit of FIG. 1 is to provide a cursor positioning signal such as a voltage magnitude that would position the cursor at a point along the distance of travel or survey of the display and a correcting signal which compensates for overshoot. The signal is shown in FIG. 2. It will be apparent to one skilled in the art that a signal such as that shown in FIG. 2 will be duplicated for each axis involved in the display. For example, on a standard two-dimensional cathode ray type display there would probably be both an x and a y signal of the type shown in FIG. 2 to position the cursor.

Referring to FIG. 1, the overall function performed is to provide a steadily rising drive voltage to move the cursor to a position and simultaneously therewith to actuate a means that will set up an overshoot control signal determined by how fast the cursor is moving and the operator's reaction time, so that when the operator signals to stop the cursor such as by releasing the cursor movement key, the overshoot control signal is applied to correctly position the cursor. The illustrative functional

circuit of FIG. 1 produces as an output the voltage signal as shown in FIG. 2 wherein at a point A a progressively increasing voltage appears that moves the cursor through region B for as long as the operator indicates desire for movement. At point C, when the operator signals termination of cursor movement an overshoot compensation signal D is provided which brings the cursor positioning voltage E to corrected level.

Referring to FIG. 1, in the analog illustration of the principles of the invention a psychomotor responsive member such as a button 1 operates to close two switches, 2 and 3. Switch 2 connects a negative voltage $-V_1$ to an integrating circuit made up of a resistance R_1 labelled 4 and capacitance C labelled 5 in series connected across an operational amplifier 6. A switch 7 is provided to zero the control voltage when desired. One side of the operational amplifier 6 is connected to reference or ground. Thus, in response to an operator depression of the cursor movement button 1, the output voltage V_c will be a linear ramp signal illustrated by region B of FIG. 2 that is determined by equation 1.

Equation 1 $$V_c = \left(\frac{V_1}{R1C} \right) t$$

where t is the time of depression of the cursor movement button 1. The movement of the cursor is stopped by release of the key 1.

In accordance with the invention a cursor controller correction signal has been developed as a result of switch 3 being closed simultaneously with depression of push button 1. This operates to connect to ground a positive (+) voltage V_2 during the duration of operation of movement of the cursor. When the switch 3 is opened as the key 1 is released, a single shot

multivibrator 8 is triggered generating a pulse of duration t_1 which operates to actuate a relay 9 and close switch 10. Through the points of switch 10 there is connected a variable potentiometer 11 and a resistor R_2 labelled 12 to the input of the operational amplifier 6. The variable potentiometer 11 provides a variable positive voltage labelled V_4 between $+V_3$ and ground through R_2 labelled 12, in the opposite direction to the voltage applied to the operational amplifier at the point between resistor R_1 labelled 4 and capacitor 5. V_3 is made proportional to V_1 but of the opposite polarity, by the inverting amplifier 13, the constant of proportionality being the ratio of resistor 14 to resistor 15.

Referring to FIG. 2, this opposite voltage operates to provide a correction signal labelled region D to the output voltage at point c so that when the cursor movement button 1 is released, the correction signal is in accordance with the relationship of equation 2.

Equation 2 $$\Delta V_c = -\left(\frac{V_4 t_1}{R_2 C}\right)$$

If a user has reaction time, t_r, then the cursor voltage will overshoot by the amount given in equation 3.

Equation 3 $$\Delta V_e = \left(\frac{V_1 t_r}{R_1 C}\right)$$

In accordance with the invention a correction is produced by making ΔV_c equal to ΔV_e as set forth in Equation 4.

Equation 4 $$V_4 = \left(\frac{V_1 R_2 t_r}{R_1 t_1}\right)$$

Thus, when the button 1 closes switches 2 and 3, the

cursor position is controlled by the ramp voltage and the release of switch 3 produces the correction signal to subtract from the ramp value. Thus in FIG. 2, the cursor positioning signal voltage V_C after moving through region B to point C will be ramped down region D by the amount ΔV_C set forth in equation 2 and this signal will move the cursor in the reverse direction to correct for the user reaction time. It should be noted that both the correction voltage and the cursor rate are proportional to the voltage V_1. Therefore, the correction will automatically increase if the cursor speed is increased by raising V_1.

Thus, in accordance with the invention, the problem of overshoot receives automatic compensation reflecting both the speed the cursor is moving and the reaction time of the operator. The correction is even more essential if the cursor speed is arranged to increase in time. Display apparatus wherein cursors have long distances to travel may be built this way. When it is desired to build acceleration into the positioning of the cursor a second serial integrating circuit is provided between the output of the operational amplifier and the output terminal. When this is done, the ramp voltage in the region B in FIG. 2 will be quadratic. The correction circuit would use the instantaneous rate voltage at the input to the second stage to develop the correction voltage.

The correction C provided in accordance with the invention will be a complex function of cursor speed, and the acceleration factors if present, as well as the length of displacement. In operation, experienced users generally attempt to compensate for their own reaction times and this compensation is a function of several variables that will be different for each

user. In accordance with the invention the user dependent reaction time and the time increment of cursor motion are combined into a single correction signal. Initially user reaction time adjustment is generally set at an average value and then incremented or decremented with experiençe with the individual user. The setting would be by adjustment of the potentiometer 11 for the functional illustration of FIG. 1.

Best Mode of Carrying Out the Invention

The preferred embodiment would be that of a microprocessor wherein the elements of the invention functionally illustrated in the sample circuit of FIG. 1 are employed digitially in a single integrated circuit substrate. Referring to FIG. 1 for the functions, the cursor location would be represented by a digital number stored in a register. There would be two tables of numbers stored in the microprocessor memory and accessed sequentially during cursor movement. The first table would represent a series of time-delays between cursor movements. For an accelerating cursor, these numbers would decrease according to the desired acceleration function. The second table would represent the correction to be applied to compensate for user reaction time. These numbers would be initially set according to an average user reaction time, and would be adjusted with use so that the specific user reaction time would be compensated.

The operation would be as follows. When the cursor movement key such as 1 of FIG. 1 is depressed, the microprocessor preferred embodiment receives a signal to increment or decrement the cursor position. It

will be understood by one skilled in the art that although the descriptions involve incrementing, the operation of decrementing would merely be the opposite.

Under such conditions, the key depression would generate an interrupt signal, and upon receipt the cursor would be moved one unit. Simultaneously, the first time-delay value would be loaded into a suitable register and decremented at regular intervals until it reached zero. At this time, the cursor would be moved another unit and the next sequential time-delay value loaded. This process would continue until the key is released. At this time, all forward motion would be disabled. In accordance with the invention, the cursor would then be moved back a number of positions based on the final rate of movement and the user's reaction time as set forth in equation 3. This is accomplished by selecting the corresponding number in the correction table and subtracting it from the cursor location register.

It will be appreciated that the invention is applicable to very many manually controllable devices other than cursor controls, for example X-Y tables in machine tools. Implementation will be readily apparent to those skilled in the art from the preceding description.

CLAIMS

1. Manually controllable device wherein the position of an element proceeds at a rate in response to a first operator signal and the operation is terminated in response to a subsequent second operator signal, the improvement for providing an operator reaction compensated end point comprising: means (4) for establishing a signal responsive to said rate; means (11) for establishing a signal indicative of operator reaction time; means (13, 14, 15) for producing an end point compensation adjustment signal based on the ratio of said operator reaction time signal to said rate signal; and means (5, 6) for establishing an end point position by applying said end point compensation adjustment signal negatively to the end point at the time of said second operator signal.

2. The device of Claim 1 wherein said each signal is provided from an analog circuit.

3. The device of Claim 1 wherein each said signal is provided by a digital microprocessor.

4. A display terminal in which depression of a key by an operator controls the speed and distance of cursor travel on a display, the improvement comprising: means for establishing a cursor motion rate value; means for providing an operator reaction time value; and means for negatively backspacing the cursor position for a number of spaces after release of said key determined by the expression:

$$\frac{\text{operator reaction time}}{\text{cursor motion rate increment.}}$$

5. The terminal of Claim 4 wherein said improvement is applied to each axis of the display.

6. The terminal of Claim 4 or 5 wherein said display is a cathode ray tube.

FIG. 1

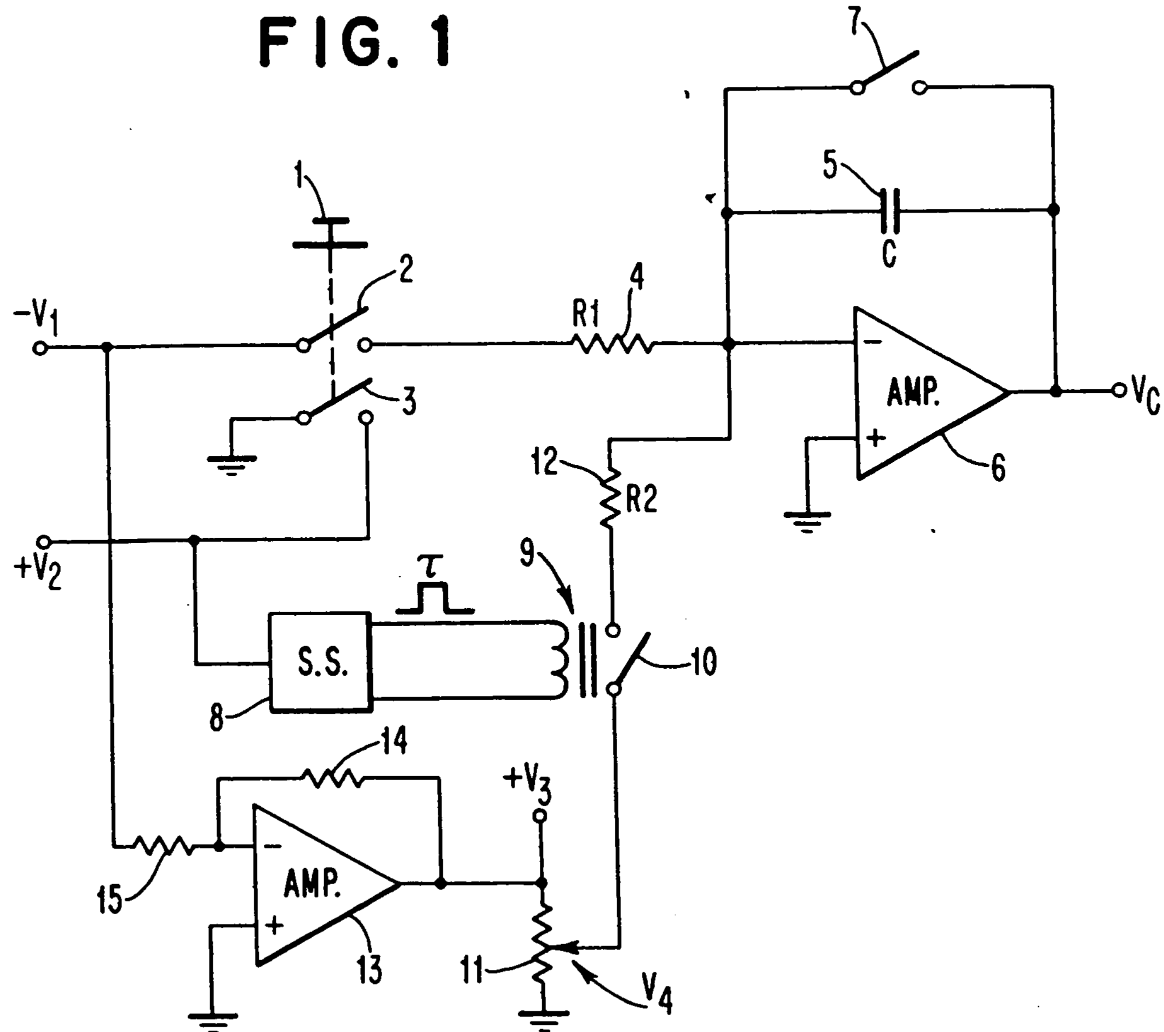
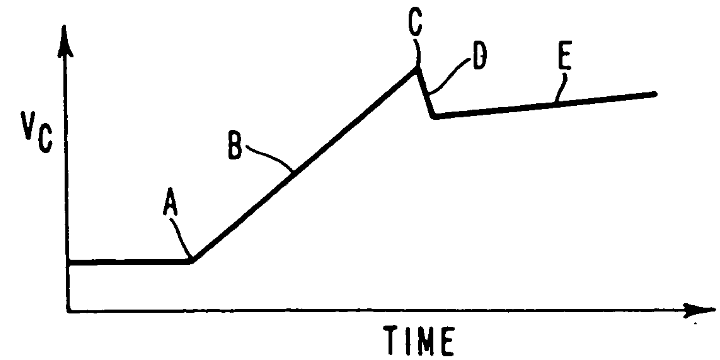

7
5
C
1
2
-V1
R1
4
3
AMP.
VC
6
12
R2
+V2
τ
9
S.S.
10
8
14
+V3
AMP.
15
13
11
V4

FIG. 2


C
D
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